2015 EFCD
Electrolysis & Fuel Cell Discussions
Challenges towards zero platinum for oxygen reduction
13-16 September 2015,
La Grande Motte, France

N-doped Carbon Materials as Zero Platinum Catalyst for Oxygen Reduction in PEMFCs

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Carbon materials have structural and textural characteristics appropriated for its use as support in electrocatalysts for Polymer Membrane Fuel Cells (PEMFCs). In this context it is remarkable that carbon nanofibers (CNFs) present high electrical conductivity; carbon xerogels (CXGs) have high surface area and large mesopore volume; ordered mesoporous carbons (OMCs) have high surface area, large pore volume and a porous structure formed by uniform sized mesopores; and graphene (G) displays a bidimensional structure with excellent electronic properties, high thermal conductivity and mechanical strength. It has been reported that when these materials are used as support for electrocatalysts containing Pt, the behaviour and activity of the catalyst are improved allowing the decrease of Pt loading [1].

Recently, it has been shown that doping these carbon materials with N, S, P and B enhances the catalytic activity for the oxygen reduction reaction (ORR) both as support and as catalyst (that is, in the absence of Pt or other noble metal in the material). In the case of nitrogen-doped substrates, this behaviour seems to be related with the presence of nitrogen sites located at the edges of the carbon structures (as N-pyridine and N-pyridone), which reduces the overpotential for the ORR. The reason is that the reaction intermediate, H_2O_2, is more strongly absorbed on nitrogen sites promoting its faster decomposition [2].

In this work, N-doped carbon materials with nitrogen content up to 14 % has been prepared by introducing the heteroatom during the carbon material synthesis process (and not in a subsequent step once obtained as commonly described in the literature). In the case of CNFs doping was performed in liquid phase [3, 4] attaining 3.5% N with 9.4% Fe. For the synthesis of N-doped CXGs, melamine was used as a nitrogen precursor (Figure 1) and the final product contained about 3.5% N. Finally, N-doped OMCs were obtained by impregnating mesoporous silica SBA-15-R2 with pyrrole [6], which allows to achieve a nitrogen content of 14%. These materials were tested as catalysts for the ORR.

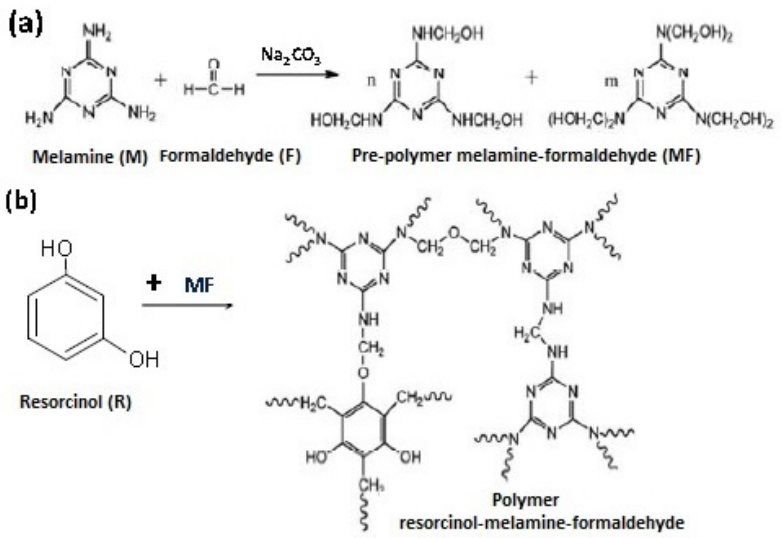

Figure 1: *(a) Reaction of melamine-formaldehyde pre-polymer (b) Addition and condensation reaction between the pre-polymer and resorcinol [5].*

References

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